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lariform bordered pits at the overlapping ends, with the exception that occasional shorter pits are present and in a position to form branched bars should the pit membranes and pit borders be eliminated. The lateral walls show perfect transition from scalariform to circular pits. Living types, therefore, preserve all stages in the transformation of scalariform tracheids into vessels with multiseriate circular pits and simple perforations; and there is every reason to believe that modification is still going on.

Many seem to be under the impression that scalariform pitting is of rare occurrence above the cycads. A close comparison of scalariform tracheids, which Wieland's material makes possible, can leave no doubt that existing forms, in dicotyledons as well as in monocotyledons, still exhibit, in the vascular elements of their secondary wood, almost complete stages in the transformation of scalariform pitting into that of the circular multiseriate type, affording a valuable criterion by which to judge the relative primitiveness of angiosperm groups. The histologic evidence is fairly in accord with the floral evidence.

The exceptional abundance of circular pits in such forms as *Vaccinium corymbosum*, noted by Jeffrey, is accentuated by the fact that, in this type, the vessels are mostly isolated from one another and in contact with wood-prosenchyma which forms circular bordered pits in common with the vessels. Scalariform pitting occurs near the pith where, occasionally, vessels are adjacent. Here occur vessels showing perfectly the transition from scalariform pits to scalariform perforations, as well as the transition stages, noted by Thompson,² from scalariform to simple or porus perforations.

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THE ORIGIN OF DICOTYLS

IT is generally conceded that the origin of the conifers is from the evolutionary point of

² Thompson, W. P., Jan., 1918, "Independent Evolution of Vessels in Gnetales and Angiosperms," *Bot. Gaz.*, LXV., pp. 89-90.

view a fairly luminous subject. Neither stem, leaf nor cone has wholly new or remote features. The group appears rather old mainly because so much of its history is known or directly inferable. Evidently, sporophyll consolidation into the hard spiny unisexual cones mainly occurred in the Permian, and by Jurassic time was complete. There is, thus, the distinct connection with the dominant Cordaites of the ancient world, and the cycads and *Ginkgo* amongst still existent types. Moreover, that *Ginkgo* was cosmopolitan, and of varied form in the Rhätic further broadens the possibilities of conifer relationship with known types, while by way of seed-ferns the several gymnosperm lines are in common carried back to Pteridophytes.

Not so the origin of dicotyls, long wholly without the range of scientific discussion. It was understood in a general way that the monocotyls did not obscure the problem. That they were either a contemporaneous or later development appeared more or less certain. Before the discovery of the cycadeoids, however, no line of attack from the viewpoint of either fossil or existent evidence seemed to carry the dicotyls beyond the Cretaceous. Back of that period the decipherable record ceased entirely. But the discovery that the cycadeoids were a varied group with flowers recalling those of magnolias, at once suggested that the origin of the dicotyls could not be wholly obscure. It was soon seen that the great extension of Magnoliaceous species in the lower Cretaceous must indicate a series of more primitive magnolias in the Jurassic. There might have been doubt as to the significance of the cycadeoid flower with its pollen-bearing synangium. But the reduced sorus of existing cycads plainly stood in the complementary relationship, just as did the cycadeoid microsporophyll and the carpillary leaf, as components of cycad fructification.

Nextly it was found by Nathorst and Wieland that the larger proportion of Mesozoic cycadales were cycadeoids, in part bearing small and reduced types of flowers. The *Wielandiella* of Nathorst with its slender bifur-

eating stems and Nilssonoid foliage proved the form of greatest interest; although very recently another related form, *Williamsoniella*, of quite equal interest from the Yorkshire coast has been reconstituted by Thomas. This has a very small perfect flower with somewhat scale-like microsporophylls, bearing, as it turns out, only a few pairs of sessile synangia. The stems are slender, and the foliage definitely Nilssonian to Tæniopterid. This relationship was in *Wielandiella* somewhat obscured by a peculiar prolongation of the midrib.

Now this definite inclusion of *Nilssonians* amongst the small-flowered cycadeoids demonstrates the presence of a great alliance related to the primitive magnolias and abundantly represented in the leafy records of the Mesozoic. For it is seen that to this group must be added not only *Tæniopteris* but *Macrotæniopteris* at least in part. In 1905 I called attention to these foliar types in Monograph XLVIII. of the U. S. Geol. Sur. in the following justifiable terms:

The genera *Nilssonia*, *Tæniopteris* and *Oleandrium* have now come to comprise numerous species of a very generalized and cosmopolitan type of leaf. As a consequence, it has become difficult, as always in such a case, to say definitely, in the absence of extended revision, where the one genus ends and the other begins. Nevertheless we have every reason to believe that at the one end of the series there are characteristic ferns analogous to such living forms as *Oleandra* and *Acrostichum*, as well as marattiaceous forms, and at the other an important list of cycadaceous forms. The closely related genera *Pterophyllum* and *Anomozamites* [now *Wielandiella*, in part] may be cited here. *Anomozamites minor* (Brongn.) Nath., as restored by Nathorst from specimens from the Rhätic of Scania, with its *Williamsonia*-like fructifications, Nilssonia-like foliage, and branching habit, is especially to be mentioned in this connection as one of the most interesting fossil plants known. This series is at the same time an exceedingly important one, covering as it does a period extending over much of the Paleozoic to the close of the Jurassic at least, a period so fertile in the evolution of higher forms.

From the Carboniferous to the Cretaceous there is, then, a great and cosmopolitan cy-

cadeoid group with simple sparsely inserted leaves. This group is especially in evidence in the Rhätic, a period of marked change in the Mesozoic plant alignment. In the Northern hemisphere the Rhätic is generally notable for megaphyllous forms, especially so in the Richmond and North Carolina coal fields; but, as I found on the eastern side of the Andes in finely stratified Rhätic shales of Argentina, there are many small leafed and even scrub or upland forms. The small extent to which these forms showed netted venation is of course the weakest link in the chain of evidence for dicotyl derivation. But it may be recalled that the presence of net-veined forms [*Dictyozamites*] is not an inference; while the perfunctory reference of the numerous net-veined leaves of the Mesozoic to ferns, rarely found fertile, rests on no sound or certain basis. The great lyrate ferns of the Rhätic, *Clathropteris* and *Dictyophyllum*, are an exception; also an adumbration of the higher net-veined types soon to become dominant.

This subject has been considered more at length in a paper in the *American Journal of Science* (November, 1914). It is there suggested that polar stocks of unknown record may account in part for the seeming gap in the dicotyl leaf series. Also it should be noted that plastic, potent upland stocks (Bailey and Sinnott), are in the strictest sense of the word corollary to the main theory of radiation of animals and plants from the polar areas (Darwin, Forbes, Rütimeyer, Saporta, Joseph Dalton Hooker, Asa Gray in the Dubuque Address of 1875, Narthorst, Wallace, Scribner, Wortman, Wieland and Matthew). In any case the negative evidence indicates small flowers for the early dicotyls from the Permian on, and these are only likely to occur in some favored or unusual locality.

It has been said that the resemblances between Cycadeoid and dicotyl wood structure are deceptive, that some Magnolias (and the Trochodendrons) have lost their vessels, and that scalariform sculpture of the dicotyledonous vessel results from the lateral fusion of circular pits (Jeffrey). Even if the first of these contentions, improbable as this now seems,

were true, it no longer need be held vital. The second has been fully and thoroughly shown by Brown to be at variance with the facts. By the simple process of segmentation of the primitive and more fern-like scalariform pits, the circular-pitted and slit-pitted modern types of vessels must arise. When the scalariform cycads and the *Araucaria*, and Magnoliaceous (*Drimys*) seedlings are adequately compared, every stage in this fundamental change, which affords the very basis of dicotyl evolution, becomes visible.

Over and above the collateral evidence now at hand, three notable generalizations of the last few years further affect our conceptions of the fossil record of the dicotyls:

Firstly, there is a very small record of the upland vegetation of past times; although the enormous extent of the unknown upland record could not be surmised so long as the alternate emergence and subsidence of the continental areas remained wholly unmapped. Yet it appears that the high upland and polar, and not the tropic or coastal fringe plants have long included the great majority of plastic forms; and it is certain that upland and polar forms moved forward during the periods of continental emergence closing geologic epochs, and were least liable to extinction during medial subsidence. That is to say, we know best the aplastic coastal fringe forms with a broken record.

Secondly, the fossil record has gradually lengthened out in the case of so many lines both animal and plant, that a nearly universal parallelism comes into view instead of a comparatively recent development from constantly dichotomizing stocks. That is, slowly converging lines replace the "paleontologic tree" of the texts; and now that these persistent lines are more clearly discerned they are rapidly being pushed back still further on purely anatomical grounds. Thus it is not only easy to admit the view of Seward that the Araucariales are distinct, but it now seems difficult to show the connection of any of the gymnospermous groups since Carboniferous times. Their resemblances are all in large degree homoplastic.

Thirdly, Bailey has found much evidence for a progressive tracheidal shortening in all woody plants from the Carboniferous on. His fuller results are awaited with the greatest interest. The wonder is that it was not discerned long since that some such general course of change formed the basis of later stem evolution. Now this leads to a very obvious conclusion as to the origin of complexity of structure in dicotyledonous stems. Taking into consideration the observations already made as to the tracheidal origin of vessels, and the general dicotyl stem features, it seems that the main order of dicotyl stem change has been, beginning some time in the Permian: (a) shortening of the tracheids, (b) segmentation of scalariform into circular pitting, (c) pith reduction and development of both medullar and radial storage tissues, (d) secondary [relative] enlargement of short types of circularly pitted tracheids coordinate with [actual] reduction of adjacent elements to the condition of fiber tracheids, (e) progressive radial sclerotization, (f) development of extreme branching in sparse-leaved shoots. In recent interesting and serviceable descriptions of Lower Cretaceous woods by Stopes¹ exactly the older features agreeing with the course of change just outlined are sharply in evidence. In the Lower Cretaceous *Aptiana* the small vessels scarcely disturb the regular radial sequence, are little larger than the wood fibers, and nearly as elongate as normal tracheids. The medullary rays are similarly old of aspect, with considerable variation in cell length and size, the short rectangular form being almost cycadeoid. Fully in accord with the views advanced, scalariform wood is a striking feature in not only *Aptiana*, but several other Lower Cretaceous genera described by Stopes.

Morphologically speaking a point has therefore been reached where dicotyls are no more isolated than the conifers. From the viewpoint of stem, foliage and flower they are separated from other groups by no impassable gap. In fact the main categories of evidence for dicotyl origin are to be found within the

¹ Brit. Mus. Cat. Mesozoic Plants, 1915.

dicotyls themselves. Among various dicotyls, which have a Lower Cretaceous record and numerous present representatives, are not only the Magnoliaceæ and Trochodendraceæ, but Berberidaceæ, Myricaceæ, Salicaceæ, Fagaceæ, Moraceæ (figs), Lauraceæ, Myrtaceæ (*Eucalyptus*). The list might be greatly extended. As a clue to the nature of the real early characters of dicotyls attention may be turned to the sassafras, poplars, elms, oaks and magnolias, all typical in the Comanchian. All these must show recognizable archaic characteristics in the seedlings; and in making comparisons with gymnosperms, *Araucaria* and the cycads afford just as critical data as the cycadeoids.

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SPECIAL ARTICLES

THE REGULATION OF BLOOD VOLUME AFTER INFUSIONS OF SOLUTIONS OF VARIOUS SALTS. PRELIMINARY NOTE

IN the recent work of Rous and Wilson¹ it was demonstrated that the disastrous effects of hemorrhage are not the result of the withdrawal of hemoglobin from the circulation. They bled an animal until the hemoglobin was reduced from 80 per cent. to 20 per cent., *i. e.*, three fourths of the original hemoglobin of the animal was removed without consequent serious effects. A reduction of four fifths, however, resulted in a somnolent, torpid condition, followed by death. Under the conditions of severe, sudden hemorrhage observed in man, the hemoglobin content is never reduced as much as these authors report.

Bayliss² has shown that the factor which makes the results of sudden hemorrhage severe is the lowered blood pressure consequent to the reduction of volume of fluid in the circulatory system. Bayliss and Rous and Wilson state that saline infusion is almost useless in sustaining blood volume; and Bogert, Mendel and Underhill³ have shown in what a surprisingly

¹ Rous and Wilson, *Jour. American Medical Association*, 70, 219.

² Bayliss, *Proc. Royal Society*, 89, 380.

³ Bogert, Underhill and Mendel, *Am. Jour. Physiology*, 41, 189.

short time infused saline solution leaves the circulation. Bayliss reports satisfactory results in sustaining blood volume when colloidal solutions of approximately the same viscosity as blood are used as infusion fluids. He used 6 per cent. gelatin or 7 per cent. acacia in Ringer's solution. Rous and Wilson have used the same solutions with the same satisfactory results. They also have used human plasma and horse serum. Human plasma has given them their best results. They dispute Bayliss's contention that the infusion fluid must have the same viscosity as blood. Hurwitz⁴ has used Locke solution containing 5 per cent. acacia for infusion in human patients and reports satisfactory results.

In the course of some experiments of a somewhat different nature, the writer has had occasion to measure the rate of disappearance from the circulation of various isotonic solutions, each containing the same cation but a different anion. In view of the timeliness of this question of maintenance of blood volume, it seemed worth while to offer at this time what information was available which had a bearing on this problem.

The solutions examined were isotonic with rabbit's blood. The bromide, nitrate, acetate, chloride, sulfate and thiocyanate of sodium were the salts used. These solutions were injected into the jugular vein of rabbits which had been anesthetized with ether. Blood samples were taken from the carotid and the dilution of the blood after injection was followed by the hemoglobin percentage, using the Haldane technic. Fifty cubic centimeters per kilo body weight, or the approximate blood volume, was injected in two minutes. The average time for the blood volume to return to normal after the injection was less than an hour for every salt used except one. This exception was the sulfate. When this salt was used the blood volume did not return completely to normal during the entire experiment. The amount of infused fluid which remained in the circulation was about 9 per cent. of the amount put in.

⁴ Hurwitz, *Jour. American Medical Association*, 68, 699.